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TACTICS AND TECHNOLOGY: HOW DO THEY AFFECT EACH OTHER?

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OUTLINE

Thesis: Research and development of new, revolutionary technologies have been extensive. The resulting military applications will drastically change the tactical nature of the battlefield.

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TACTICS AND TECHNOLOGY: HOW DO THEY AFFECT EACH OTHER?

Research and development of new, revolutionary technologies have been extensive. The resulting military applications will drastically change the tactical nature of the battlefield. To cover every technology currently under consideration would be lengthy and beyond the scope of this paper. Rather, it is the intent of this paper to detail selected technological innovations and their tactical implications.

GROUND WARFARE

INDIVIDUAL SOLDIER SYSTEMS

The development of personal protective devices, coupled with individual communication capabilities, will result in an electronically and mechanically-enhanced 21st Century warrior. One project under development, the Soldier Integrated Protective Ensemble (SIPE), employs a helmet-mounted display which presents information about the terrain and the local threat, a lightweight communications device for either voice or data transmission, and remote sighting systems for small arms and ballistic/laser eye protection.

Also included is a ballistic protective vest, microclimatic cooling undergarment with portable power source, and a computer complete with joystick. (39:82)

Similar to the SIPE is a British-designed "Infantryman 2000" concept. This system includes a lightweight computer system with 100 megabytes of memory, integrated with a helmet-mounted display and a soldier's weapons system. The computer-generated information will include 3-D digital maps, sight and sound analysis, and target positioning, all exhibited on a heads-up display. Weapons systems will include computer-targeted missiles maintained via fiber optic cable. The gun system is aimed through a helmet-mounted sight. It will employ high-explosive, anti-personnel, smoke, and illumination rounds. (39:84)

Protection from projectiles and contaminants will be provided by a lightweight undersuit. This undersuit is internally-cooled with filters and fans and is covered with an infrared (IR) masking material. A hard cast ceramic material, resistant to penetration, will provide direct-fire and shrapnel protection to the individual.

The fielding of these systems will create an individual capable of accomplishing missions far exceeding those of today's soldier. Increased firepower and protection, wider dispersion, and individual communication capability will

provide armed forces with a more autonomous soldier able to accomplish his mission in a much shorter time period.

The logical step following advanced protection and armament is a system to enhance the individual combatant's load-bearing capability. Two systems currently under development are the Man-Amplifier Exoskeleton and the Powered Exoskeletal Suit for Infantryman (PITMAN). The Man Amplifier Exoskeleton would enable the operator to lift up to 5,000 lb. loads. This application would aid material handling personnel as well as combat personnel. Since much of the earth's land surface cannot be traversed by wheeled vehicles, human amplifiers/exoskeletons would enable infantrymen to carry heavy weapons and supplies over rugged terrain. Using break-away cuffs located at various points on the exoskeleton limbs, pressure sensitive points will furnish simple control mechanisms with signals to activate movement of the limbs to mimic the moves of the operator.

The PITMAN concept relies on brainwave-induced commands. A 200 lb. robotized garment equipped with a mechanical actuator in the legs enables the operator to jump and sprint at levels far exceeding the greatest Olympians. Additionally, the system will include voice-actuated anti-armor and anti-aircraft missiles mounted on hard points on the exoskeleton and backpack. (39:83)

COMBAT VEHICLES

Close-in defense weapons are critical to the protection of high value mobile assets. These systems would be similar to those employed as self-defense systems aboard ship, but on a smaller scale. Initially, these systems are designated for command and control vehicles.

Combat vehicles produced almost completely of fiber-reinforced polymer (FRP) materials, i.e. plastics, can now be produced. Plastic hulls and turrets offer better crew survivability because of the non-spalling nature of the material and vastly reduced radar signatures over steel or aluminum. Added benefits include resistance to rust, improved thermal characteristics, and greatly reduced weight.

ANTI-ARMOR

Trends in anti-armor include use of hyper-velocity kinetic weapons. Foremost in this technology is the Advanced Kinetic Energy Missile (ADKEM), currently scheduled for field launch and guided flight during FY 94. Comparable in size and weight to the Hellfire missile, the ADKEM consists of four rocket motors configured around a missile centerbody. This centerbody will contain the systems guidance components and kinetic energy penetrator. The missile will reach speeds of 2100 meters per second within 400 meters of launch point with a minimum range of 150

meters. ADKEM will be capable of defeating future armor targets up to five kilometers away and fixed or rotary wing aircraft out to 7-10 kilometers. Also, ADKEM will allow the firing platform to fire from a defilade position, increasing crew survivability. These capabilities allow ADKEM to double the battlefield effectiveness of current and near current line-of-sight weapons platforms.

INDIRECT FIRE SUPPORT

Quick reaction for support of light forces may be provided by the Low Intensity Conflict Rocket System (LICRS). This system will be light enough (less than 8,000 lbs.) to be transported by KC-130 and CH-47 aircraft. Using five or six inch diameter rockets in the 100-150 lb. class, the LICRS would have the range and accuracy comparable to the Multi-Launch Rocket System (MLRS). The saturation fires anticipated by LICRS will significantly improve the fire support capability of light and airborne forces. However, this system is not projected for concept development until 1994.

NON-LETHAL WEAPON SYSTEMS

Special Purpose Low Lethality Anti-Terrorist Munitions (SPLLAT) are especially effective against terrorist or regular forces when employed in densely populated areas or hostage situations. Two examples of SPLLAT are the Accuracy Systems Ordnance Corps' M424 Thunderflash and M470 Magnum

Thunderflash. These grenades can be further divided into two types. These are Stun and Diversionary/Distraction grenades. Of the two types, the Stun is the more powerful. Designed to incapacitate individuals in close proximity of the blast, the explosion actually takes place outside the body of the grenade, eliminating lethal fragments associated with standard grenade explosions. Diversionary/Distraction grenades are not designed to stop individuals in close proximity to the blast, but only to disrupt their activity.

Another example of SPLLAT is the STINGMORE. This munition is a concentration of rubber sting balls rather than lethal pellets. Similar to the M18A1 claymore mine, this weapon is expected to be used to protect both indoor and outdoor sensitive areas from intrusion, and will be useful in situations when deadly force is not appropriate.

Training personnel to attack and seize buildings and fortifications has always been a dangerous evolution because of ricochet rounds. However, training without the benefit of actual firing creates an unrealistic and possibly fatal sense of security. The IMPAX, a small arms munition, addresses the realistic training needs of the soldier. This cartridge fires a projectile that is harmless, though somewhat painful. It will not penetrate clothing, walls, or glass and can be used both indoors and outdoors with the M16

rifle. Also, a 9mm version is being developed for use with the standard sidearm of the U.S. armed forces.

ROBOTICS

To increase man's survivability on the future battlefield, robots and unmanned vehicles will take the place of man during certain dangerous missions. The Teleoperated Mobile All-Purpose Platform (TMAP) will provide flank security while route reconnaissance along a highway will be performed by a larger Teleoperated Vehicle (TOV). Both systems are remotely-controlled by a human operator or computer through a command, control, and communications (C3) link. The primary C3 link will use fiber-optic cable with a radio/receiver being used as a backup link. The vehicles could be dispersed to any location permitted by the C3 link, allowing the battle to be brought to the enemy anywhere, regardless of operator location. (14:10)

SUMMARY

Technological advancements in ground systems will allow us to (1) provide more autonomy through the use of individual protective systems designed to increase effectiveness and survivability; (2) field a lighter, more highly protected armor vehicle through the use of fiber-reinforced polymer materials in place of homogenous rolled steel; (3) expand the battlefield by defeating the armor and aircraft threat to include reactive armor and other kinetic

energy weapons; (4) increase survivability and firepower in urban and hostage environments with the use of Special Purpose Low Lethality Anti-Terrorist Munitions (SPLLAT); and (5) decrease the risk of injury to personnel in a high threat environment by providing security and battlefield intelligence through the use of unmanned vehicles.

AERIAL WARFARE

DECOYS

An approach under current consideration is the use of decoys. Decoys are used to deceive enemy air defense systems by presenting an image that either mirrors or amplifies that of other aircraft. Researchers are pursuing multi-spectral decoys which combine radar frequency, infrared, and electro-optical threat detectors into a single expendable platform. One such system under development is a towed Advance Airborne Expendable Decoy (AAED). This decoy consists of an aerodynamically-stable electronic payload, deployed on a towline, distant enough from the aircraft to prevent damage from explosion missiles.

AUTONOMOUS MISSILES

A cruise missile carrying multiple sub-munitions will be launched against a target area without a controller actually identifying the individual targets. The weapon

orbits the battlefield in a preprogrammed flight pattern, differentes between targets, and then attacks high priority targets. The targets are programmed into the missile's memory. An electronic eye scans the terrain below, comparing it to targets programmed into the system. Once a target is identified, the weapon attacks that target with sub-munitions. These munitions are designed to be effective against hardened targets such as bunkers, surface-to-surface missile facilities, and airfields. (35:12)

SUMMARY

Future aerial technology will allow us to (1) use expendable multi-spectral decoys to divert enemy anti-aircraft and surface-to-air missiles; and (2) deploy an autonomous cruise missile capable of seeking out and destroying preprogrammed high priority targets without risking personnel.

NAVAL WARFARE

AMPHIBIOUS

Projection of power to foreign shores has always been dependent on the naval services. A new type of amphibious assault ship is being designed to carry Marines, helicopters and landing craft. This ship will be equipped with a small flight-deck, hanger-deck, well-deck, and cargo space. All

critical staff spaces will be centrally located allowing greater coordination and interaction within the staff. Amphibious operations will thus be greatly enhanced with the introduction of this class of vessel.

SUB-SURFACE

In conjunction with the amphibious capability, the navy is also developing surface and sub-surface combatants. Air-independent propulsion systems now being fielded have greatly improved conventional diesel submarine performance. Air-independent propulsion systems give diesel submarines the ability to operate at speeds of up to ten knots for several days without coming to the surface for snorkeling. This ability to remain submerged for longer periods has created a dilemma for our Navy because third world nations will be able to compete with nuclear submarines in quiet-running techniques. These submarines will most likely operate along the continental shelves where it is very difficult to conduct Anti-Submarine Warfare (ASW) operations due to all of the natural noises. (27:12)

Smaller ships and more reliance upon unmanned underwater vehicles are currently envisioned by the Navy. These ships, both manned and unmanned, will be deployed from mother ships and possess a variety of multipurpose sensors. Technical issues include the extent to which small, deployed ASW vehicles can rely upon information from satellites and

other airborne command and control aircraft such as the Navy's E-2C and the Air Force's Airborne Warning and Control System.

To aid in commmand and control, the Navy is researching a system where satellites in low orbits of only a few hundred miles provide platforms for low-powered laser communications. Laser communications are favored for secret transmissions because an enemy will have difficulty intercepting a narrow laser beam. Also, these low-orbiting satellites greatly reduce the cost of building and launching satellites into a higher orbit where more powerful lasers are required when communicationg with submarines 23,000 miles below. Deployment of laser capable satellites of this type are not expected until around 2005. (33:1)

SUMMARY

Advancement in naval technologies will allow us to (1) project an amphibious task force to distant shores with greater ease with new classes of amphibious shipping; (2) defeat air-independent propulsion submarines operating along the continental shelf through the use of submersable platforms, both manned and unmanned; and (3) interface with airborne platforms, both aircraft and satellites, to better track and engage threat vessels and communicate on a secure channel.

NUCLEAR WARFARE

Few experts predict there will be any dramatic breakthroughs in the area of nuclear weapons in the near future. Emphasis will be placed on improving the efficiency of those weapons systems currently employed. (5:20)

EARTH PENETRATING TECHNOLOGY

One of the more advanced technologies being examined is associated with the Interim Earth Penetrator Weapon (IEPW). This weapon would field a warhead designed to withstand the shock of plunging many feet into the ground before exploding, destroying hardened and dug-in targets. The weapon would also have naval applications as well; submarines under polar icecaps could be targeted. The earth-penetrating technology was first tested successfully in 1987, with penetration depths reaching 3 to 13 feet in soil and 4 to 7 feet in ice.

The earth penetrating warhead (EPW) program dates back to 1960. Warheads were produced for use on the Pershing II missile, but they are now being dismantled with the weapon system never being produced beyond the experimental stage.

IMPROVED GUIDANCE SYSTEMS

Additional nuclear force systems are also being examined. Guidance systems that would allow us to attack mobile strategic targets such as rail and road-mounted

intercontinental ballistic missiles are being investigated. Two such systems are the Advanced Strategic Missile System (ASMS) and the Strategic Relocatable Target (SRT) system. (34:50) These systems might be used to incorporate an air-breathing vehicle inside a ballistic missile re-entry vehicle. The air breathing minicruise missile would orbit in a predetermined search pattern after separation until the target was located. Current development of this system is hampered by the lack of an onboard processing and sensor system. National-level laboratories are pursuing the sensor technology required to bring this concept into reality.

An additional concept is the Maneuvering Reentry Vehicle (MaRV). The MaRV would serve as a counter to the continued modernization of the joint Anti-Ballistic Missile (ABM) system around Moscow. To function, however, the MaRV requires real-time terminal guidance from reconnaissance satellites to allow targeting of mobile sites. The obstacle confronting the deployment of this system though, is the inherent plasma build-up associated with these vehicles during reentry into the atmosphere. The plasma buildup disrupts communications and distorts signals.

SUMMARY

Technological breakthroughs in the nuclear arena will allow us to (1) negate adversary's advantages gained from hardened and mobile nuclear systems by the employment of

earth-penetrating warheads; and (2) allow us to accurately engage the adversary's mobile strategic systems through improved guidance systems on our missiles.

SPACE WARFARE

STRATEGIC DEFENSE INITIATIVE

Since the invention of the ballistic missile, the notion of developing an anti-ballistic missile (ABM) capable of destroying inbound missiles has existed. ABM sites, limited under SALT I treaties, have been operational since 1973. The only U.S. site, located in Grand Forks, S.D., was dismantled in 1976, but research into the technology has continued.

In March 1983, President Reagan called on U.S. scientists to make nuclear weapons obsolete. Shortly thereafter, the Strategic Defense Initiative (SDI) was launched. Funds doubled for research and development into ballistic missile defense (BMD) research.

The purpose of SDI was not to construct BMD weapons, but rather to investigate a wide range of BMD technologies and assess the feasibility of such systems for future development. Despite a current cut in budget of $1.8 billion, research continues at a rapid pace. A presidential

decision on whether to deploy a BMD system, by most estimates, is two to three years away.

SURVEILLANCE, ACQUISITION, TRACKING, AND KILL ASSESSMENT

The first necessity for an effective BMD system is the ability to detect a launch, then track a missile with enough precision to engage and destroy that missile. Surveillance, acquisition, tracking, and kill assessment (SATKA), are the key tasks that must be performed. (21:101)

Different phases in the ballistic missile's trajectory necessitate different SATKA techniques and technologies. For instance, to track the boost phase, the system must monitor over one thousand Soviet missiles launched from land and sea, not to mention missiles from non-Soviet countries with ballistic missile capabilities. Heavy emphasis on research and development has been placed on boost phase SATKA because within minutes missiles begin to dispense their warheads and decoys, considerably increasing the task of defense .

The task of launch detection is currently being conducted by early-warning satellites, but these infrared (IR) systems have limitations. These satellites can only lock onto a missile's exhaust plume, not the actual missile. This is adequate for initial detection, but is not suitable for tracking and weapons pointing.

The Boost Surveillance and Tracking System (BSTS) is a boost phase monitoring technology that has both near and long-term goals. Initially, its purpose was enhancement of early warning satellites, but ultimately this system will provide a boost phase monitoring capability adequate for interception purposes.

The tracking of objects in the post-boost and mid-course phases is extremely difficult compared to boost-phase tracking. The number of objects to be monitored could exceed 100,000, and warheads would have to be distinguished from decoys, debris, and chaff. (21:102)

Despite the complexity of post-boost and mid-course tracking, many promising active and passive sensors are being researched using longwave infrared and lowlight-level technology. Phased-array microwave radars and ultraviolet laser radars are being investigated for possible employment in space, on aircraft, or on the ground. Lasers and particle beam systems which can deduce variations in temperature or velocity are also being researched, but fielding of these systems is not expected anytime soon.

These technologies would ultimately be incorporated into the Space Surveillance and Tracking System (SSTS). This system would monitor both ballistic and satellite targets. Data would be accepted from post-boost phase sensors, support mid-course interception systems, and

provide data to terminal-phase sensors, greatly enhancing the overall BMD effort. (21:104)

Tracking of objects in the reentry (terminal) phase of trajectory is less complex than in the post-boost and mid-boost phases. In the terminal phase, decoys and debris decelerate more rapidly than actual warheads, making identification of the target easier. Identification and tracking data would be passed over to the interceptors' sensors. Research is currently being conducted to improve tracking in this stage.

DIRECTED ENERGY WEAPONS

The prospect of Directed Energy Weapons (DEW) earned the SDI the nickname "STAR WARS". While the technology involved is ambitious, it has proven to be highly feasible in the past seven years of research. DEW would use high power lasers or particle beams to destroy targets. While inroads have been made in this area, many technical hurdles remain, the most notable being the generation of sufficient power output to destroy missiles and the inadequacy of beam focusing and aiming systems for weapons purposes. (21:108)

One of the most advanced systems being examined is the chemical laser. This system is powered by the reaction of two gases in a combustion chamber, the most productive pairs to date being hydrogen/fluorine and deuteronium/fluorine. Current laser systems emit at two megawatts with the ability

to add on generator modules to boost power output to 10 megawatts. An output of at least 25 megawatts, however, is desirable for weapons purposes. (21:108)

The Large Optics Demonstration Experiment (LODE) is exploring the feasibility of producing high-quality beam control devices. Laser acquisition, pointing, and tracking (APT) is another major area of research. The long term goal is to produce an extremely accurate laser-pointing device for targeting purposes.

While chemical laser programs are currently the most feasible, long range DEW projects focus on excimer and free-electron lasers, which would most likely be ground based because they are large and heavy. The main advantage of excimer and free-electron lasers is their short beam wavelength. These beams disperse less, allowing them to employ smaller optical systems. The disadvantage of these lasers is their bulk and large power requirements, which limit them to ground-basing. Additionally, they require higher quality optical surfaces than space-based systems.

The main thrust of excimer and free-electron lasers has been the construction of orbiting mirrors which serve to reflect the beams emitted from ground-based systems. The construction of these mirrors has proven to be no easy task, due to the difficulty of producing the high-quality mirrors.

Ground basing of lasers also presents the problem of atmospheric distortion.

Recent tests of an orbiting mirror have proven very successful. The Relay Mirror Experiment (RME), conducted during November and December of 1990, successfully proved that a beam could be launched from a ground based emitter, travel through space, reflect off a satellite 279 miles above earth, and hit a ground target one meter in diameter. (37:28) This level of accuracy is critical if this system is to be used for weapon destruction. Future experiments will examine problems of atmospheric distortion.

Particle beam weapons are another focus in the area of DEW. Because of their unsuitability for long range, particle beams are being examined for use in terminal phase defense systems. They have been demonstrated to be effective at an altitude of 50 to 375 miles. These weapons are a more distant prospect than laser weapons but hold considerable long-term promise. Current research is concentrated on methods of generating and steering high power beams and on the development of lightweight systems for possible space basing.

X-ray lasers are another type of DEW, but the employment of such a system would involve a nuclear weapon surrounded by laser rods. Explosion of a nuclear device would cause emission of intense x-rays that would damage or

destroy nearby missiles, either physically or electronically.

KINETIC ENERGY WEAPONS

Research into Kinetic Energy Weapon (KEW) technology has been intense, with weapons being examined that would be capable of intercepting a ballistic missile from the boost phase to the terminal phase. KEW's destroy missiles by collision. Two basic modes have been examined, one firing multi-unguided projectiles and another firing fewer, heavier projectiles equipped with guidance systems. (21:120)

One of the primary KEW systems being evaluated is the Brilliant Pebbles space-based intercepter program. Each 50 kilogram, 3 foot Brilliant Pebbles interceptor orbiting the earth would be designed to detect a missile launch and guide itself to the projectile, destroying the missile through impact. Current plans call for 5,000 Brilliant Pebbles interceptors to be employed to destroy missiles during the boost phase, 3 to 10 minutes after launch. (7:42)

Recently, however, officials have been examining Brilliant Pebbles possible application in the mid-course phase as well, adding approximately 25 minutes to interception time. (7:42) This re-examination of Brilliant Pebbles' utility comes in light of increasing proliferation of ballistic missiles in the Third World and the increasing mobility of Soviet missiles. As the area of emerging

threats expands, three to ten minutes seems insufficient time for a Brilliant Pebbles interceptor to reach a target. (7:42)

Technical challenges in hardware miniaturization, power, and computer software already face the current system, as each Brilliant Pebbles interceptor requires lighter solar arrays, lighter structures, and smaller thrusters than past space vehicles. (7:42) Broadening Brilliant Pebbles' scope would increase technical challenges, as it would be required to distinguish between warheads and decoys, and it would require more sensitive sensor capability.

Ground-based interceptors are also being investigated that would destroy incoming missiles during the mid-course and terminal phases. Such interceptors previously employed during the 1960's and 1970's were equipped with nuclear warheads, but increased accuracy will allow future systems to use non-nuclear devices.

There are two types of ground-based interceptors: endoatmospheric and exoatmospheric. The former destroys missiles inside the atmosphere while the latter destroys missiles outside the atmosphere. Research programs are in progress in both areas on sensors, guidance systems, warheads, fuzing methods, and propulsion techniques.

Two major projects in endoatmospheric interceptors are the Small Radar Homing Interceptor Technology (SRHIT) missile and the High Endoatmospheric Defense Interceptor (HEDI). The SRHIT missile, designed for terminal phase interception, maneuvers by firing small rockets mounted around its circumference. The HEDI is a higher altitude weapon capable of destroying incoming missiles at ranges from 9 to 37 miles. (21:127)

One exoatmospheric program in progress, the exoatmospheric Ground Based Interceptor-Experimental program, was recently put in jeopardy when SDI officials announced plans to develop a new Endo/Exoatmospheric ground-based interceptor which could function both inside and outside of the atmosphere. The new interceptor would be much more expensive and require additional sensors and maneuvering controls in order to fulfill its mission. This system, along with Brilliant Pebbles, would make up the Exoatmospheric Re-entry Vehicle Interceptor System (ERIS). ERIS, a scaled-down system from what was originally planned, would include about 1,000 space-based Brilliant Pebbles interceptors and 750-1,000 ground-based interceptors.

ANTI-SATELLITE SYSTEMS

American efforts to produce an effective antisatellite capability have been disrupted over the years by continually shifting priorities and rationales, indecision, and

technical problems. (1:4) The technology for an anti-satellite system is less demanding than that of a BMD system, due to the predictability of a satellite's orbit. Nonetheless, certain satellites can reach speeds in excess of 23,000 mph, so one should not view them as sitting targets waiting to be shot from the sky.

As late as January 1991, the U.S. Army was examining two antisatellite systems. One of these systems was a kinetic energy missile traveling at 5 to 10 km per second, destroying satellites by force of impact. The satellite would be destroyed by a sheet of synthetic material which would slam into the satellite as it passed by, much like a flyswatter. This method of destruction was also intended to reduce the amount of space debris resulting from a satellite kill.

The second system being examined was known as the Mid-Infrared Chemical Laser, a large ground-based laser capable of destroying a satellite by its sensors. This directed energy weapon was viewed as less promising than the "flyswatter" technology.

Both of these systems were canceled by the Pentagon in the new Department of Defense six year plan. This decision, approved by the White House, was made despite the fact that over 1.8 billion dollars had already been spent over the last ten years developing an anti-satellite capability.

(1:4) Production was to have started on the "flyswatter" system in 1995. This decision effectively took the U.S. Army out of the anti-satellite picture indefinitely.

The most successful U.S. anti-satellite program to date has been the U.S. Air Force's Miniature Homing Vehicle (MHV). The MHV program, initiated in 1977, consisted of a two stage missile carrying the MHV which would be launched from a modified F-15 aircraft. The MHV, a cylindrical device 12 inches in diameter and 13 inches long, would be guided to the target by eight infrared telescopes, which would lock onto the target and feed information back to computers. Maneuvering capability would be provided by 56 single-shot rockets commanded by the computer. The MHV would destroy the satellite by ramming into it. The impact would be roughly equivalent to a 16" shell from a battleship. This system, after successful testing in 1988, was put on the shelf when Congress voted to prohibit the testing of systems against targets in space. So, while the U.S. does not currently possess an anti-satellite capability, the technology has been developed and tested.

SUMMARY

Technological advances in space research will allow us to (1) reduce the reaction time in engaging adversary's ballistic missiles by employing boost-phase monitoring technology; (2) establish an overall command and control

network for Ballistic Missile Defense (BMD) by incorporating all of our assets into an overall surveillance and tracking system; (3) engage incoming ballistic missiles in a variety of ways, using directed-energy and kinetic energy weapons, both ground and space based; and (4) engage the adversary's satellites from ground, space, and aerial-based means, hampering his ability to use satellite systems for surveillance, reconnaissance, and communication.

CONCLUSION

Ever since man first faced off on the field of battle, tactical advantages have been gained by those who have had the foresight and initiative to expeditiously employ new technology. These technologies have not only shaped the way we fight, but also where we fight. By defining the future battlefield, technology impacts the entire spectrum of conflict with new and revolutionary approaches to warfighting.

It is essential that tactical applications be incorporated into the development and testing of future weapons systems to ensure they meet the needs of the future combatant. This will facilitate the successful integration of new technologies on the global and extra-terrestrial levels. Political, military, and industrial leaders must

keep abreast of advances in technology to avoid the fielding of systems that fail to meet the tactical requirements of a dynamic battlefield.

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